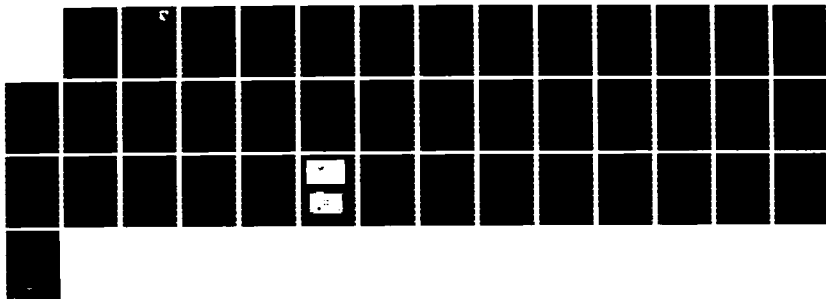


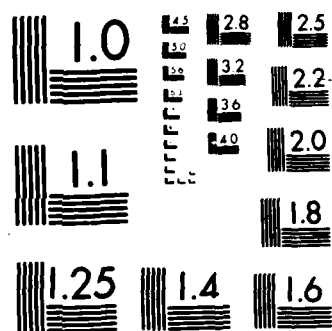
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## HUMAN REAL TIME PERCEPTION IN NOISE

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ranged from 1.75 to 14.0 seconds. Results indicate that subjects overestimated time intervals and that the greatest errors occurred for the shortest time intervals and in noises that changed during the task. Also, female subject estimates of time intervals were consistently shorter than those of the male subjects. These findings are compared to earlier research on time estimation and verify that the RTPA provides a reliable and sensitive measure of the perception of real time in noise.

## ABSTRACT

### HUMAN REAL TIME PERCEPTION IN NOISE

A novel device, the Real Time Perception Analyzer (RTPA), has been developed to measure the perception of real time as well as simple and choice reaction time under microgravic conditions on board the space shuttle. This study examined only real time perception; reaction times were not measured. The RTPA real time perception task produces a target dot that moves from left-to-right across a narrow, horizontal light bar. A vertical marker is positioned almost two inches beyond the right end of the light bar. The subject's task is to push a switch when it is estimated that the target dot has moved beyond the end of the light bar, a region where the dot is no longer visible, and reached the vertical marker. Sixteen subjects performed the time perception task under various conditions of quiet and noise exposure. Errors consisted of underestimations or overestimations of the actual time intervals which ranged from 1.75 to 14.0 seconds. Results indicate that subjects overestimated time intervals and that the greatest errors occurred for the shortest time intervals and in noises that changed during the task. Also, female subject estimates of time intervals were consistently shorter than those of the male subjects. These findings are compared to earlier research on time estimation and verify that the RTPA provides a reliable and sensitive measure of the perception of real time in noise.

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## PREFACE

This research was accomplished in the Biological Acoustics Branch, Biodynamics and Bioengineering Division, Harry G. Armstrong Aerospace Medical Research Laboratory, Aerospace Medical Division (AMD). The effort was accomplished under Project 7231, "Biomechanics in Aerospace Operations", Task 723121, "Biocommunications", Work Unit 72312104, "Bioacoustics-Biocommunications Research". Capt Michael Stock, Project Officer, and MSGT Vernie Fisher were responsible for this effort. The idea and motivation for this effort were provided by Dr. H. E. von Gierke, Director of the Biodynamics and Bioengineering Division.

Personnel in the Acceleration Effects Branch, Biodynamics and Bioengineering Division, merit special recognition for outstanding scientific and technical assistance without which this study could not have been accomplished. Mr. David Ratino provided the RTPA for use in the study and served as the point of contact that provided substantial reviews, suggestions and contributions from himself, Dr. George Potor and Dr. Daniel Repperger. Mr. Charles Goodyear, Systems Research Laboratory, Dayton, Ohio also provided significant assistance as well as the statistical analysis of the data.

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## HUMAN REAL TIME PERCEPTION IN NOISE

### BACKGROUND

The environmental conditions of space missions may cause differences in the perception and performance of astronauts that are so subtle that they go unnoticed in most typical operations. Manned space vehicles, prior to the space shuttle, provided little opportunity to investigate such questions because onboard space and weight limitations prohibited the use of conventional measurement apparatus. The relatively large space and payload available on the Space Shuttle and the National Aeronautics and Space Administration's (NASA) continuing initiatives to accomplish in-space experiments now provide the opportunity to examine various questions of importance relative to manned space activities.

The "Time Compression Syndrome" (7), a situation in which time appears compressed to astronauts during certain portions of space missions, is a subject of current interest and importance. NASA space shuttle astronauts have reported that, during their missions, certain time intervals appear to be shorter than they believe they should be. In particular, the astronauts have noted that they do not seem to have enough time to complete all the tasks that they must perform during the reentry phase. Although these tasks are practiced repeatedly and performed successfully on the ground where there are no apparent time interval problems, the perceived time compression in space is reported. Historically, the astronauts have had little or no tasking on the reentry phase of space missions until the implementation of the space shuttle program. Since the astronauts now play a part in the landing phase of the mission, their performance during this operation is critical and an examination is needed of the observed real time perception in space.

### INTRODUCTION

Dr. Daniel W. Repperger, et al., (9) responded to this reported perceptual anomaly by developing an instrument to measure reaction time and time estimation capabilities of astronauts under conditions of space flight. This instrument, which is called the Real Time Perception Analyzer (RTPA), has been evaluated and accepted by NASA for an experiment which was flown on a 1985 mission of the Space Shuttle Program.

Initially, the time perception task on the RTPA was conceptualized as an adaptation of measurement techniques utilized about thirty years ago to investigate time judgements of subjects exposed to stresses such as fatigue and noise (5). The RTPA instrumentation concept was for a small, lightweight, hand-held, portable device that would reliably measure the same attributes of time judgements as those measured with standard sized laboratory instrumentation.

A prototype was constructed and several experiments were conducted to evaluate the feasibility of the RTP analyzer, to obtain design information, to develop the device and then to establish baseline data on its measurement capabilities. One of the first of these efforts was the preliminary work reported in a graduate thesis (6) which demonstrated the feasibility of the measurement concept and served as a basis for its further development. Additionally, it was concluded that the device provided rigorous and consistent measurements of reaction time and time perception.

Characteristics of the operation and performance of the RTPA were further defined by investigations of such factors as rate of motion of the target, size of the visual display window and feedback to the subjects on their response accuracy. Data from these formal and informal studies were used to finalize the design of the RTPA hardware unit and in the development of procedures for the operation of the reaction time-time perception tasks.

The final configuration of the RTPA unit is shown on a desk chair in front of an experimental subject in Figure 1A and in a closeup of the front panel of the unit in 1B. It is a microprocessor-based, self-contained, lightweight unit measuring approximately 12" by 7" by 5" with a weight of about 6 lbs and a volume of about 438 in<sup>3</sup>. The unit can be used on a surface such as a table or a desk chair, as shown, or as a hand-held portable device. The rotary "off-on" switch on the lower left is also used to select one of four modes of task operation. Each mode, or ID# as shown on the unit, presents the time perception stimuli in a different random order (Table 1). The unit will retain subject response data on only four randomized runs after which it must be dumped to a microcassette recorder (Pearlcorder S801).

The time estimation target display area at the top consists of a narrow, horizontal window approximately four inches long with a short vertical bar marker one and three quarters of an inch beyond the end of the window. The target is a red dot that moves at a constant rate from the left side of the window to the vertical bar marker. The task is to monitor or follow the target in the visible

portion of the window and to estimate the duration of the invisible portion of the target's sweep from the point of disappearance to the vertical marker.

The subject response button located near the right edge of the unit is a two-position rocker switch that is activated in either position (up or down) for the time estimation study. The small red light immediately above the on/off subject selection switch is illuminated when the estimate of a subject exceeds the actual time of a trial. The windows in the center indicate the trial or run and the time of the response. The time window, the four lights between the windows and the switch and the two different positions on the rocker switch are used only for the reaction time modes of the RTPA.

The RTPA instrument presents three different tasks that measure time estimation, simple reaction time and choice reaction time. The study described in this report utilized only the time estimation task; reaction time was not measured.

The Real Time Perception Analyzer development and the time perception experiments described above follow the early work of Jerison described in the 1958 report, "Time Judgements, Acoustic Noise and Judgement Drift" (5). However, none of the work accomplished with the RTPA unit evaluated its sensitivity to the measurement of time perception in noise, which was a key element in Jerison's work. Further, in order for the RTPA to be a useful measurement tool aboard the space shuttle as well as in other applications it was necessary to determine its performance reliability when used with subjects exposed to acoustic noise environments. This report describes a laboratory study of the performance of the RTPA analyzer with human subjects in acoustic noise environments.

#### ASSUMPTIONS

The research on time estimation in acoustic noise accomplished by Jerison is widely accepted. Results of his work using the masked or disappearing target method include such findings as (1) the actual time intervals were lengthened or overestimated, (2) the interval estimation time was judged to increase with repetition of the task and (3) estimates of time intervals were systematically raised when the level of the noise changed at the time of the disappearance of the target. In addition, he noted that estimation errors varied directly with the magnitude of the acoustic exposure; errors increased with increasing levels of acoustic noise exposure.

The scientific area dealing with the effects of noise exposure on task performance exhibits some uncertainty. Noise exposures influence performance only on certain tasks;

not all tasks are affected. These effects usually involve performance degradation but in some instances the opposite effect of enhancement is observed. It is important to learn if the RTPA analyzer is one of the tasks that is influenced by noise exposure, and if it is susceptible, to determine or quantify the characteristics of these effects.

The RTPA was developed on the basis of the laboratory apparatus and experimentation employed by Jerison. The work in this study was configured to more or less replicate the conditions of that experimentation, using the RTP Analyzer as the measurement instrument instead of the laboratory equipment. This work was accomplished on the premise that the RTPA analyzer is a reliable instrument for the measurement of real time perception in noise, if the results of the study are in agreement with those found earlier in the laboratory and reported by Jerison.

#### APPROACH

The performance of volunteer subjects on the RTPA time estimation task was measured in various combinations of noise and relative quiet. Combinations of the noise (106 dB(A))\* and quiet (69 dB(A)) were paired with the visible and invisible periods of the RTPA task in the respective orders of (1) noise-noise, (2) noise-quiet, (3) quiet-noise and (4) quiet-quiet. The actual durations of the masked target time estimation portions of the task were 1.75, 3.5, 7.0, 10.5 and 14.0 seconds. These intervals represent the periods during which the target dot was invisible to the subject or roughly one-third of the total sweep time of the target dot. Errors were overestimations and underestimations of the real time intervals. The criterion measure was defined as the ratio of the estimated time to the actual time (estimated/actual time) of a trial.

#### EQUIPMENT AND MATERIALS

##### Experimental Subjects

Sixteen trained volunteers (8 male and 8 female) with experience as subjects in psychoacoustic studies participated in this investigation. All were recruited from the general civilian population and were paid an hourly rate for their participation. All subjects exhibited normal hearing; hearing levels no greater than 15 dB at the standard audiometric test frequencies from 500 Hz to 6000 Hz.(2). Subjects were fully trained on the procedures and requirements of this investigation prior to data collection. All subjects participated in all conditions of this study.

Volunteers were members of subject panels that participated in experiments on a daily basis. As members of these panels each individual had signed a Subject Consent

form regarding the laboratory activities in which they agreed to participate. Subjects were permitted to voluntarily discontinue participation at any time during the study. This experiment was conducted under AAMRL Protocol, 83-58-02, Human Exposure to Acoustic Energy, 1986, (3) which insured that volunteers would experience only those noise exposures defined as safe by the Air Force Regulation, AFR 161-35, Hazardous Noise Exposure (1) and approved by the Armstrong Aerospace Medical Research Laboratory, Human Use Review Committee.

#### Facility

The test facilities are housed in the Biological Acoustics Laboratory and consist of a hearing testing room, a noise exposure room and a control room. The hearing testing room is a semi-anechoic chamber that minimizes sound reflection and background noises that might interfere with the measurement of hearing. A Grason-Stadler 1305, discreet tone automatic audiometer was used to measure the hearing of the subjects.

The noise exposure room is a reverberation chamber with highly reflective surfaces. This room was equipped with a loudspeaker system that provided the noise conditions used in the study. The RTPA instrument and the subject were located in the noise exposure room for the data collection sessions.

The experiment operator and the additional supporting instrumentation were located in the control room which was adjacent to the noise exposure chamber. The experimental sessions were controlled from this room. The experimenter monitored the subjects during test through a large observation window.

#### Instrumentation

The arrangement of the instrumentation used in the experiment is shown in block diagram format in Figure 2. The sound chamber contained the loudspeaker system that broadcast the noise exposures, a Bruel and Kjaer microphone that monitored the level and spectrum of the noises and the RTPA analyzer. In the control room, a General Radio 1382 noise generator fed a pink noise signal to a Hewlett Packard 8056A filter set which shaped the spectrum for the high level noise exposure and to Spectra Sonic Equalizers which shaped the low level noise spectrum. The shaping channels fed a special RTPA Noise Controller designed to interact with the RTPA and switch the noise on/off or off/on at the moment that the target disappeared during a trial. The output of the Noise Controller fed a preamplifier, crossover/equalizer and then the power amplifiers that drove the loudspeakers.

A Zenith Z-120 computer was used to collect the response data from the RTPA. The interface box configured the RTPA output data into digital signals that would be recognized by the computer. Data were stored on 5¼ inch diskettes and presented to a mainframe computer for analysis. A Bruel and Kjaer 2131 Spectrum Analyzer was connected to the monitoring microphone in the sound chamber and used to continuously monitor the spectra and levels of the noise exposures during all test sessions.

## EXPERIMENTAL CONDITIONS

### Noise Conditions

The spectra and levels of the noise conditions were configured to duplicate the stimuli used by Jerison, however the high level of the noise exposures in his study exceeds that allowed by the current Air Force Regulation 161-35, Hazardous Noise Exposure. The high level noise exposures used by Jerison (108 dB(A)) are allowed for only 8 minutes which is too brief a time period to complete the time estimation task. Consequently, the spectrum of the noise was slightly modified and the level reduced to 106 dB(A) to allow the subjects adequate time in the noises to complete the task. The high level noise at 106 dB(A) is permitted by the Air Force standard for about eleven minutes each day. The low level noise at 69 dB(A) is permitted for 24 hours per day and was replicated for the study.

The noise conditions, although slightly altered for the higher level, should be considered the same as those used by Jerison for the purposes of this study. The octave band levels of the noise conditions used by Jerison and those used in the RTPA study are shown in Table 2. The 69 dB(A) conditions are virtually identical and the higher level conditions for both studies are so similar as to be indistinguishable from one another by an observer. The high level noise condition is designated N (loud) and the low level condition is designated Q (quiet).

The RTPA noise controller was integrated with the RTPA in such a way as to automatically switch the noise on or off, consistent with the experimental design, at the moment that the target dot disappeared from the visible window. This provided the two experimental conditions in which the noise was switched from high to low level (off) or from low to high level (on) when the target became invisible. The two other conditions involved either the high level or low level noise during both the visible and invisible portions of the estimation task trial. The onset of the noise was controlled by a 500 millisecond ramp function to avoid surprise or startle among subjects which often occurs with exposures to noises that have an instantaneous rise time.



The experimental design called for four noise exposure conditions; (1) the 106 dB(A) noise during the entire task, (2) The 106 dB(A) noise during the visible portion of the task and switched to the 69 dB(A) noise for the invisible portion of the task, (3) The 69 dB(A) noise for the visible portion and the 106 dB(A) noise for the invisible portion and (4) the 69 dB(A) noise during the entire trial.

#### Real Time Intervals

On the basis of earlier work with the RTPA, it was determined that target time intervals, during which the target was masked or invisible to the subject, of 1.75, 3.5, 7.0, 10.5 and 14.0 seconds would be used in the study. Although this range covered only a portion of the time intervals used by Jerison, it was expected to provide an adequate definition of performance for comparison with the earlier data. The only observable difference for the experimental subject from trial to trial was a change in the rate at which the target dot moved from left to right in the viewing window when a change was made in the time estimation condition.

#### Experimental Design

The experimental design called for each subject to participate in all sessions, thus acting somewhat as his/her own control. Each subject completed four days of testing in the same week with no sessions separated by weekends. Sessions were conducted at approximately the same time each day. Prior experience indicated that a learning curve was not involved in the performance of the time estimation task, that full familiarization was achieved in two runs. The first day of the study was used for practice and familiarization with the test procedure.

The randomized experimental design is shown in Table 3. Two of the sixteen subjects were assigned to each row. The subjects received feedback about their performance only on the first day, no feedback was given on days 2, 3, and 4. Only data from days 2, 3 and 4 were included in the analysis.

#### PROCEDURE

On the initial visit, the hearing threshold levels of the prospective subjects were measured and evaluated. Subjects were dismissed from the study who did not satisfy the criteria of hearing threshold levels of 15 dB or better at all test frequencies in both ears. During the experiment, subjects received a hearing test at the beginning and at the completion of each test session

Subjects with hearing threshold levels that satisfied the criteria of the study were provided an orientation briefing that began with general comments on the nature of the experiment. Instructions to the subjects (Appendix A) were provided in written form and questions were discussed with the experimentors. Operation of the RTPA and examples of the noise exposures were demonstrated to the subject. Subjects were advised to avoid such activities as tapping or counting to keep time during the time estimation task. The subject participated in the four experimental conditions called for in the experimental design after the orientation was successfully completed.

The subject was seated at a desk chair with the RTPA unit before him inside the noise exposure room. The experimenter set up the noise condition called for by the design. The RTPA apparatus was operational and ready to begin when the two green lights flashed at a slow rate of about 2 per second. The subject started the task by pressing the response switch in either direction. A red target light moved from left to right in the visible window toward a vertical mark to the right of the window. The target always moved at a constant rate through both the visible and invisible portions of the run to the vertical mark. At the completion of a trial on day 1, the time window provided feedback by indicating the time estimated by the subject who could make adjustments on subsequent trials. The unit automatically presented the next trial to the subject until all trials in a condition were completed. The run window indicated the number of trials remaining in that condition. Each real time stimulus was presented twice during a run. During each of these runs, one of the four noise conditions was experienced by the subject.

At the completion of all four test conditions each day, the subject moved to the hearing testing room to accomplish a post-test audiogram. The 106 dB(A) noise condition was sufficient to cause mild temporary hearing threshold shifts in a very small portion of the subjects. The post-test hearing measurements were accomplished to monitor this possibility. This procedure was followed until each of the subjects completed the four days of the experiment.

Subjects were advised at the initial session that factors outside the experimental situation could have an effect on their responses during the testing sessions. They were encouraged to exercise some control over factors such as sleep, food, drinks such as coffee, medication and the like, and to maintain similar conditions for the days in which they participated as subjects.

## RESULTS AND DISCUSSION

Data were treated by an analysis of variance with the ratio of the estimated time to the actual time as the dependent variable. The analysis of variance is summarized in Table 4. Noise condition, real time interval, day, and sex were the fixed variables with subject as a random factor.

#### Noise Conditions

The average time intervals for each of the four noise conditions, collapsed over all the other variables, were overestimated by the subjects. The means for the Quiet-Noise condition (largest error) and for the Noise-Noise condition (smallest error) are statistically different ( $p \leq .01$ ). The mean responses for each noise condition and the approximate 95% confidence intervals are presented in Figure 3.

Subject responses were affected most when accomplished in noises that changed during the task. The subject estimation times were lengthened by a significant amount when the noise condition was changed from quiet-to-noise. This reaffirms a Jerison finding that has been considered by some to be one of the most important results of the original study. The ranking of the noise conditions from the largest to smallest overestimation is Quiet-Noise, Noise-Quiet, Quiet-Quiet and Noise-Noise.

Performance tasks that are affected by noise commonly show greater effects in the presence of changing rather than non-changing noises, even at higher levels. Consequently, the findings of this and the Jerison study are in consonance with this general observation on task performance in noise.

Jerison reported that noise exposures with different levels for the stimulus (visible) and response (invisible) periods for the masked target task lengthened the time judgements relative to those involving the same noise level. Results of this study confirm this finding, however neither study provides information about the importance of when the noise change occurs during the task, except as measured.

On the basis of general effects of noise on some performance tasks, it would seem likely that a similar effect might also occur when the change in noise did not coincide with the change from stimulus to response mode on the RTPA. For example, the effect of lengthening the time estimation might also be observed when the change from quiet-to-noise occurs when the target dot is positioned elsewhere than at the end of the target viewing window at the moment it disappears. Although it was not addressed in this RTPA evaluation study, the question should be of interest in future studies of real time perception in noise using the masked target method.

This study was not designed to specifically verify Jerison's findings that the degree of estimation error in noise is related directly to the magnitude of the noise exposure, i.e., higher noises show greater errors. Although only two levels of noise were employed (106 dB(A) and 69dB(A)), some tendencies were observed. The two continuous noise exposures showed the smallest errors, even though one was the highest level noise of the study. The two changing noises showed the two highest errors. As noted earlier, changing noises are typically more disruptive than continuous noises, particularly at the same level, provided the measurement task is sufficiently sensitive to identify the effect. This study also showed that responses to the changing noises contained more errors than those to the continuous or non-changing noises. In general, it is expected that tasks that experience degraded performance in noise will also show decrements that increase with increased levels of noise exposure. However, the 106 dB(A) noise-noise condition did not show the most errors in this study.

#### Time Estimation

The mean subject responses for actual times were overestimations or lengthening for essentially all conditions. The largest errors occurred for the 1.75 second condition and the errors progressively decreased with increasing time to the smallest error for the 14.0 second time interval. The indifference interval did not occur for the Quiet-Noise condition; it occurred at 10.5 seconds for the Quiet-Quiet and the Noise-Quiet conditions. The indifference interval for Noise-Noise did not occur at any of the actual measurement times but is estimated from the data to be approximately 11.5 seconds. The means of the ratios of the estimated to the actual times are shown in Figure 4 as a function of noise condition.

Overall, the response data of the subjects is orderly and well-behaved showing a range in mean responses of only 0.05 or less at all of the actual times except 1.75 seconds. At 1.75 seconds, the quiet-noise condition which displayed the greatest error, extends this range to about 0.10. The statistically significant differences found for main effects of noise are not readily evident from these data.

These subject time judgement errors in noise are consistent with those reported by Jerison in that intervals were overestimated in virtually all conditions. However, the range of the time intervals as well as the magnitudes and patterns of these errors were quite different. The five time intervals examined by Jerison ranged from 3.12 seconds to 48.12 seconds whereas the RTPA study intervals ranged from 1.75 seconds to 14.0 seconds. The errors of the actual

time estimations for each noise condition for both studies are shown in Figure 5. The RTPA data show a very orderly progression as a function of the orderly change in the stimuli (1.41, 1.26, 1.12, 1.01, 1.00). This function indicates that the RTP time estimation task is a sensitive measure in that small changes in the actual times are accompanied by clear differences in the average responses. The original task used by Jerison (5) must be considered relatively insensitive at the four short time intervals because the averages of the estimated to the actual times, collapsed over noise conditions, show only slight differences (1.37, 1.39, 1.38, 1.31) over a relatively wide range of actual times (3.12 through 24.12 seconds).

Data taken with the RTPA instrument are also very consistent for each time interval, showing ranges of mean scores for the noise conditions of approximately 0.095 to 0.035. The variations among noise conditions at each time interval in the Jerison data are considerably larger ranging from about 0.30 to 0.15.

The magnitudes of the estimations are similar for the shortest time conditions and differ markedly as the actual estimation times are increased. It is believed that the observed differences between these two sets of data are attributable to the differences associated with the measurement instruments and experimental environments. The operations of the tasks are sufficiently similar to be explained under the same theory of time perception, an area of discussion that will not be a part of this study.

Overall, these data agree with Jerison in that actual time intervals were overestimated by the subjects. However, neither the magnitudes of the errors nor the pattern of the responses confirm his results.

#### Sexes

The differences in the average responses between males and females, with males showing the larger errors, are statistically significant, consistent and free of interactions. These orderly performance changes with progressively changing time intervals are evident for both sexes. Differences are largest at the shortest time interval and change progressively to become smallest at the longest time. The response errors for actual times are shown for the male and female subjects collapsed across noise conditions in Figure 6. Each data point is the average of two runs and the four noise conditions.

Variations in the ratios of estimated to actual times of the main effect of sexes were statistically significant ( $P=.0279$ ). The means for each sex across estimation times were essentially the same for the four noise conditions

(Figure 7). The overall average of the errors of the females (1.087) was less than that for the males (1.228). There was no effect of the noise conditions on these errors for either the females (range of about 0.03 across the four noise conditions) or the males (range of about 0.05) as individual groups.

Although the size of each subject sub-sample is relatively small, the nature of these data suggest that time estimation responses of male and female subjects may be different; the overestimations of the males are significantly greater than those of the females using the RTPA. A discussion of reasons for such basic sensory perception differences between sexes is not within the scope of this paper. However, additional work to further investigate the nature and extent of this finding with larger subject samples appears appropriate.

#### Repeat Measurement

Differences among the mean responses as a function of test days were not statistically significant ( $P=.6969$ ). The overestimations of test day two (day one was practice) were slightly increased on day three by about 0.02. However, the day four estimations were either about the same as day three or they decreased by about 0.01. Contrary to these data, Jerison showed a progressive increase in overestimations or lengthening of judged time intervals over the three days of that study. The analysis of his data showed an effect for days that was statistically significant beyond the  $P=.02$  level.

#### Time Perception in Space

The RTPA was utilized aboard a 1985 space shuttle flight to measure the astronaut's perception of brief time intervals under microgravic conditions. (Ratino) Four astronauts were trained to perform the task about three weeks prior to shuttle lift off. Data were collected on each of the two days prior to lift off (preflight, L-1 and L-2), on three days during the flight (D2, D3 and D4), on the day of landing (R + 0) and three days later (R + 3).

The grouped estimations of time by the four subjects for the day prior to launch (L-1), the last flight data day (D4) and the day of recovery (R + 0) are presented in Figure 8. The response patterns are similar to other RTPA data with the briefer time periods overestimated and the longer time periods underestimated. The indifference intervals for the data occurred within the range of actual times of about 7 to 10 seconds.

An important feature of these data is the systematic overestimations and underestimations of the actual time

intervals. A progressive increase in overestimation was observed with increased time into the mission for actual times of less than twelve seconds. The maximum overestimation was at the shortest time of two seconds. Actual times were underestimated for the 12 and 16 second conditions. The differences in the mean errors between the day of landing (R + O) and days L-1 and D4 were statistically significant ( $p \leq .05$ ). These findings are consistent across subjects.

This information suggests that during a space mission the ability to estimate brief time intervals changes as the mission progresses ("mission" includes pre-flight, space flight and post-flight activities), at least for missions of about five to seven days. The changes are in the form of overestimations and underestimations of actual times relative to perceptions under typical ground based conditions. The pragmatic consideration may be that very brief events appear to be happening more rapidly in perceived time and/or that longer times than normal are required for these brief events. The perception of time expansion, as suggested by the underestimations at the longer time intervals, has not been reported by astronauts.

However, the data do not demonstrate a strong relationship with the microgravic condition alone, otherwise the D4 instead of the R + O data should have exhibited the largest deviations and the effect should have been absent from the R + O data. The phenomenon is not a component of space adaptation because it is reported by astronauts during reentry and is present after landing. Additional measurements are required with a larger subject population and during longer space missions. At present, neither the extent of the compressed time perception nor its mechanism is clear.

#### RTPA in Noise and Space.

Reliability of RTPA performance may be seen in Figure 9 in which real time perception measured during a space mission is compared to that measured in noise. The similarities among the two sets of data are reasonable with both showing the patterns of response that feature overestimations of actual times. Each set of measurements was made under quite different conditions of environment, actual estimation times, subject populations and with different RTP Analyzers.

The noise conditions data were collected on trained laboratory subjects under highly controlled conditions. These data are very well behaved with small ranges of relative error at each actual time and with very good accuracy (values close to 1.0) at the 10.5 and 14 second conditions. The space conditions data were collected on

only four astronauts, under different environmental conditions, on different and non-consecutive days, and under various conditions of fatigue and feelings of well being. These data show more scatter than the laboratory data, however the values are comparable. The major variations in the data occur at the long time intervals. The better scores of the noise data at the longer times may be due to the training of the laboratory subjects and the more favorable environmental conditions.

#### SUMMARY AND CONCLUSIONS

The scientific literature abounds with time estimation research. Various theories and hypotheses provide explanations of how humans accomplish estimates of the passage of time. This study avoids such considerations and focuses on the narrow, pragmatic question of how well does the RTPA function as a measurement tool for real time perception in noise of brief intervals.

Among the findings it was shown that the actual time intervals were overestimated for noise conditions and that the greatest errors occurred when the noise level changed and increased during the time perception task. Overestimations were also observed for all actual time intervals and the greatest errors occurred at the shortest actual times of 1.75 and 3.5 seconds. There were no substantial differences in performance among the three test days.

The differences in errors between males and females was statistically significant and the mean data were free of interactions, with females showing the smaller errors. This is an unexpected finding with this small sample size and the question deserves further investigation.

Finally, the similarities among RTPA time perception performance measured during the space mission and during exposure to noise are reasonable and consistent.

Overall, these findings are in very close agreement with the earlier laboratory work of Jerison and are interpreted as indicating that the RTPA time estimation task constitutes a good measurement tool for assessing the perception of real time. The data are quite consistent showing small variations across noise conditions at each actual time. The data show an orderly progression of responses consistent with successive changes in the stimulus. Small stimulus changes produce correspondingly small changes in subject responses also demonstrating that the RTPA task is a sensitive measure of real time perception in noise.



FOOTNOTES:

\* dB(A) is the symbol for the sound level of acoustic energy measured by a frequency weighting network (A-Weighting) on noise measurement instruments. A-weighted sound level descriptions of noise exposure correlate highly with human response to noise and effects on speech and hearing. A-Weighting (dB(A)) is an international descriptor of noise for purposes of hearing conservation.

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TABLE 1. Randomized Orders of Presentation  
of the Actual Time Intervals

Time Interval Sequences for the  
Four ID#'s on the RTPA Rotary Switch

<u>Order of Presentation</u>	<u>ID#</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1	3.5	1.75	10.5	7.0
2	14.0	3.5	1.75	10.5
3	7.0	10.5	14.0	3.5
4	1.75	7.0	3.5	14.0
5	10.5	14.0	7.0	1.75
6	7.0	10.5	14.0	3.5
7	10.5	14.0	1.75	7.0
8	3.5	1.75	7.0	14.0
9	1.75	7.0	3.5	10.5
10	14.0	3.5	10.5	1.75

TABLE 2. Noise Spectra from the RTPA Study  
and the Original Jerison Study

Octave Band Sound Pressure Levels (dB re 20uPa)				
Octave Band Hz	<u>Jerison Low Noise</u>	<u>RTPA Low Noise</u>	<u>Jerison High Noise</u>	<u>RTPA High Noise</u>
20-63	*57	57	63	63.5
63-125	57	57	65	68.8
125-250	58	55.7	81	84.2
250-500	49.5	48.8	94.5	95.5
500-1000	50	50.8	98.5	98.9
1000-2000	53.5	54.5	103	99.2
2000-4000	57.5	59.8	103.5	99.6
4000-8000	67.5	67.5	104	100.0
A-Weighted Levels	69.0	69.0	108.5	106.0

\*Jerison's data converted from old to new octave bands.

TABLE 3

RTPA Experimental Design: Presentation  
Sequence of the Experimental Conditions

<u>SUBJECT</u>	<u>DAY 1 &amp; 4</u>	<u>DAY 2</u>	<u>DAY 3</u>
1	NQ4 QQ3 QN1 NN2	QQ1 NN4 NQ3 QN2	NN3 NQ1 QN4 QQ2
2	QQ1 NQ2 NN4 Qn3	NQ3 QN1 QQ2 NN4	QN4 NN2 QQ3 NQ1
3	QN3 NN1 QQ2 NQ4	NN4 NQ2 QN1 QQ3	NQ1 QQ3 NN2 QN4
4	NN2 QN4 NQ3 QQ1	QN2 QQ3 NN4 NQ1	QQ2 QN4 NQ1 NN3
5	QN1 NQ3 QQ4 NN2	QQ3 NN4 QN2 NQ1	NN1 QN3 QQ2 NQ4
6	NQ3 NN2 QN1 QQ4	NN1 QQ2 NQ4 QN3	QQ3 NQ1 NN4 QN2
7	NN4 QQ1 NQ2 QN3	NQ4 QN1 NN3 QQ2	QN2 QQ4 NQ1 NN3
8	QQ2 QN4 NN3 NQ1	QN2 NQ3 QQ1 NN4	NQ4 NN2 QN3 QQ1

LEGEND: Q = Low Level Noise, 69 dB(A)

N = High Level Noise, 106 dB(A)

1, 2, 3, 4 = ID # on Rotary switch where each  
presents a different randomized  
order of the actual time intervals

Example: QN3 means, low level noise for visable portion of  
trial and high level noise for invisable portion  
of trial with presentation order on setting #3.

TABLE 4. Summary Analysis of Variance:  
Real Time Perception in Four  
Different Noise Conditions  
N=16

<u>SOURCE</u>	<u>DF</u>	<u>SUM OF SQUARES</u>	<u>ERROR TERM</u>	<u>F-VALUE</u>	<u>P-VALUE</u>
Noise	3	.19	Noise*Subj (sex)	2.96	.0431
Actual	4	22.91	Actual*Subj (sex)	20.33	.0001
Day	2	.07	Day*Subj (sex)	.37	.6969
Sex	1	4.72	Subj (sex)	6.02	.0279
Subj (sex)	14	10.97	error	43.24	.0001
Noise*	12	.26	error	1.20	.2814
Actual					
Noise*Day	6	.10	error	.91	.4896
Noise*Sex	3	.02	Noise*Subj (sex)	.32	.8103
Noise*	42	.91	error	1.19	.1906
Subj (sex)					
Actual*Day	8	.10	error	.70	.6888
Actual*Sex	4	.96	Actual*subj (sex)	.85	.4971
Actual*	56	15.78	error	15.55	.0001
Subj (sex)					
Day*Sex	2	.25	Day*Subj (sex)	1.26	.2993
Day*	28	2.79	error	5.49	.0001
Subj (sex)					
error	769	13.93			
Total	954	73.83			

## APPENDIX A

### SUBJECT INSTRUCTIONS: REAL TIME PERCEPTION ANALYZER

This is an experiment to measure an individual's ability to judge or estimate short intervals in time. You will be asked to estimate the time it takes a moving target to reach a vertical cross hair. Try to guess the time as accurately as possible. There are no right or wrong answers. During your training you will have access to the analyzer itself, but for your convenience if you don't have the analyzer in hand you may refer to the symbolic representation of it on page three. We will be conducting the experiment in two noise conditions, quiet noise and noise. In both cases you will respond to the analyzer prompts, but in this experiment you will not be wearing any hearing protection. The noise exposure will not be harmful, but it may be louder than you are used to in the VOCRES tests without hearing protection. This experiment is also being flown on a space shuttle mission to measure the astronauts reactions in that environment. You will be helping us to gather some baseline data to compare against their results.

The target will be visible only during the first part of each run. The target will disappear during the second portion of each run, but the rate of travel of the target will be the same as when it was visible in the window. You will have feedback on how close your answer matched the actual time during the first day, the familiarization and training day.

The test itself consists of four different runs. The order of the runs will be mixed at random, but they will consist of the four types of runs. The noise condition will consist of a continuous noise throughout the entire run. The quiet condition will consist of the quiet noise throughout the entire run. Then there will be two mixed noise condition runs. For the third condition the loud noise will be on during the visible segment of the test, with the quiet condition on during the hidden portion of the test. The fourth condition will be just the opposite of the third, where the quiet noise will be on during the visible portion of the test and the loud noise will be on during the hidden portion of the test. We are measuring the entire time interval from the time the run starts to the time you say the target reaches the vertical cross hair. You will indicate the time you estimate the target reaches the vertical cross hair by pushing the response switch. The response switch may be pressed either in the up or down direction.

NOTE: On the third page is a symbolic representation of the analyzer front panel.

The experiment operator will give you the analyzer with an ID number selected and ready to run. The flashing green lights are the indication that it is ready.

#### ANALYZER OPERATIONAL DESCRIPTION

The two green lights should flash at a slow rate of about 2 per second. This indicates that the apparatus is working and ready.

Press the RESPONSE switch in either direction to start the experiment.

#### JERISON TASK (MOVING LIGHT TEST)

A red light (target) will move from left to right across the light bar area at various rates of speed. The object is to estimate the time the target will arrive at the vertical cross hair (a vertical mark) located to the right of the light bar by pressing the response switch at that time. The target will always continue to move at the same rate during the second portion of the trial when it will not be visible to you.

The "RUN" display will count-down the number of trials remaining and at the end of the session the two green lights will flash at a rapid rate (approximately 6 per second) indicating data is ready to be recorded.

Try to be as accurate as you can. During the feedback session on the first day, the number in the lower time display tells you how close you were to the exact time. If you estimated the rate exactly, the time display would be 00. This time display would correspond with digits from left to right: 1st '0' is the number of seconds, 2nd '0' is tenths of seconds, 3rd '0' is hundredths of seconds and the 4th '0' is thousandths of seconds. In other words, the time display window shows the time difference between your choice and the exact time to the vertical cross hair in units of milliseconds.

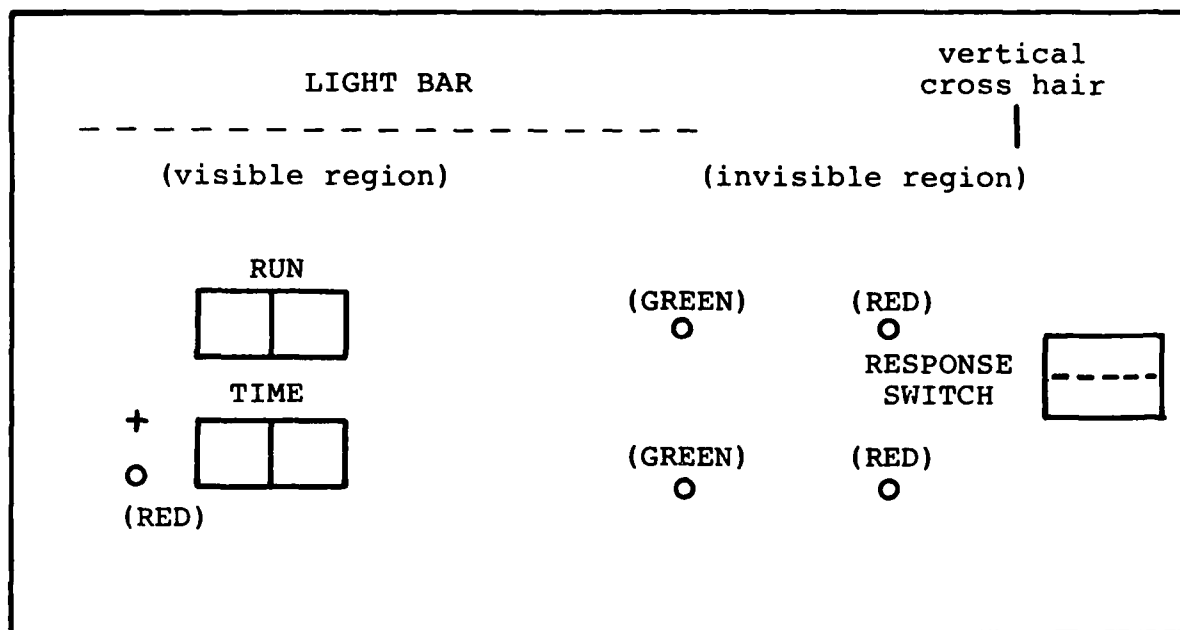
Additionally, the light marked with a "+" will light if the estimate is too long. If it does not light, the estimate is early.

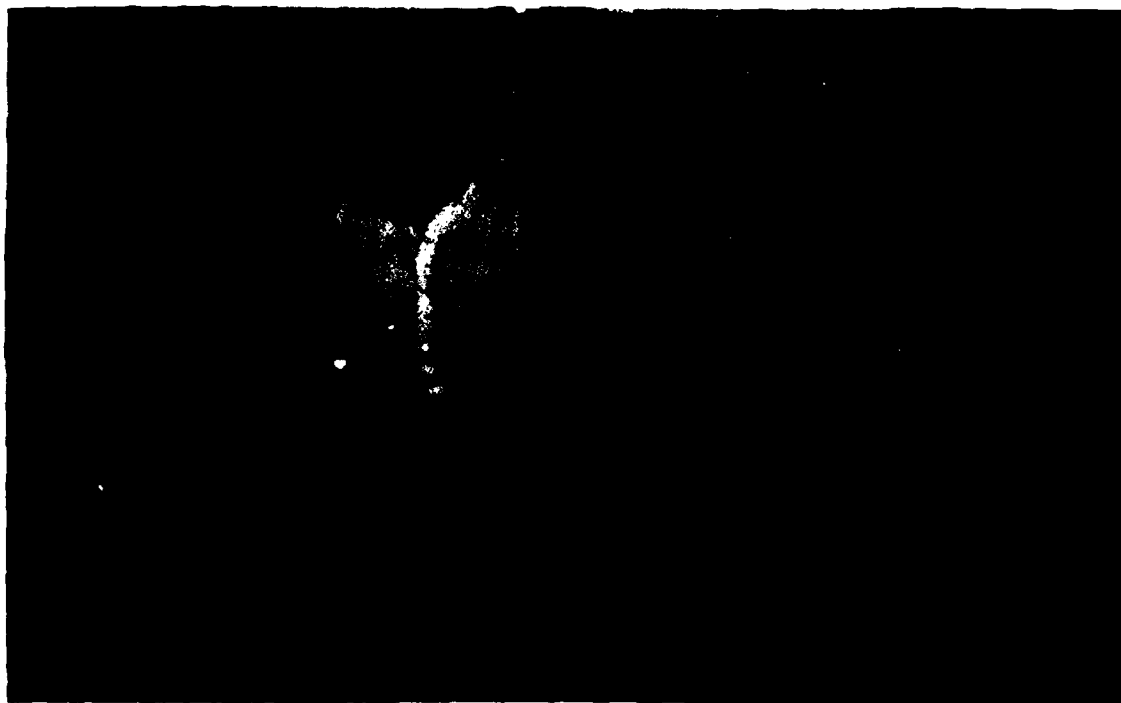
During the three days of testing the feedback time display will be disabled.

AT THE END OF THE RUN CALL THE TEST ADMINISTRATOR OR FOLLOW DIRECTIONS AS APPROPRIATE.

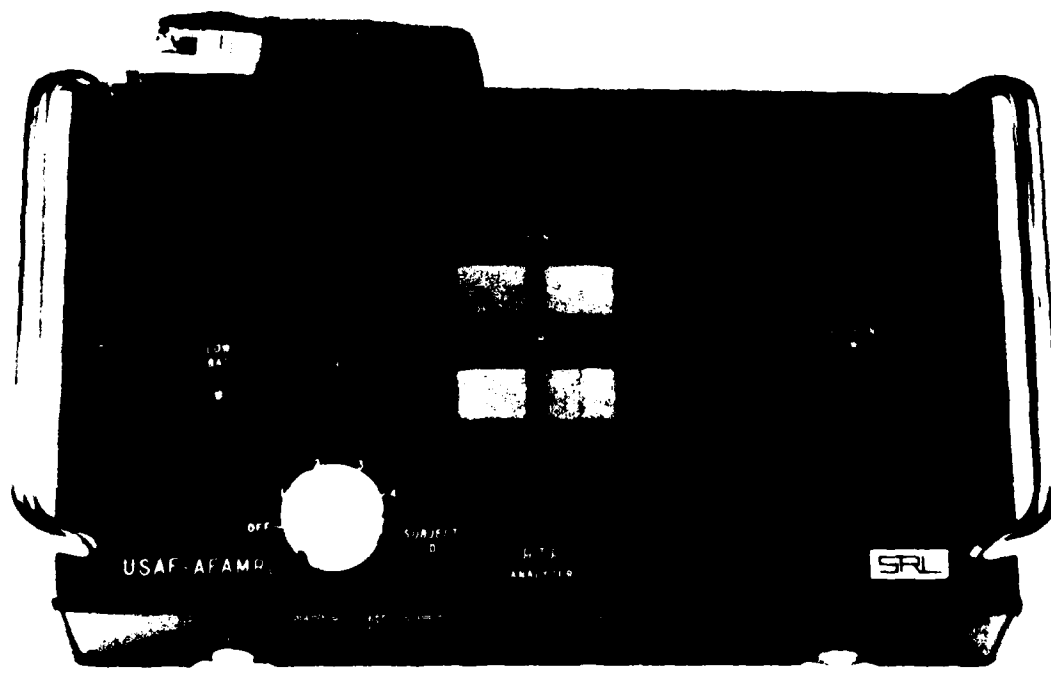


REAL TIME PERCEPTION ANALYZER \_ FRONT PANEL





**FIGURE 1A. RTPA POSITIONED ON A DESK CHAIR IN FRONT OF AN EXPERIMENTAL SUBJECT**



**FIGURE 1B. CLOSEUP VIEW OF FRONT PANEL OF THE RTPA**

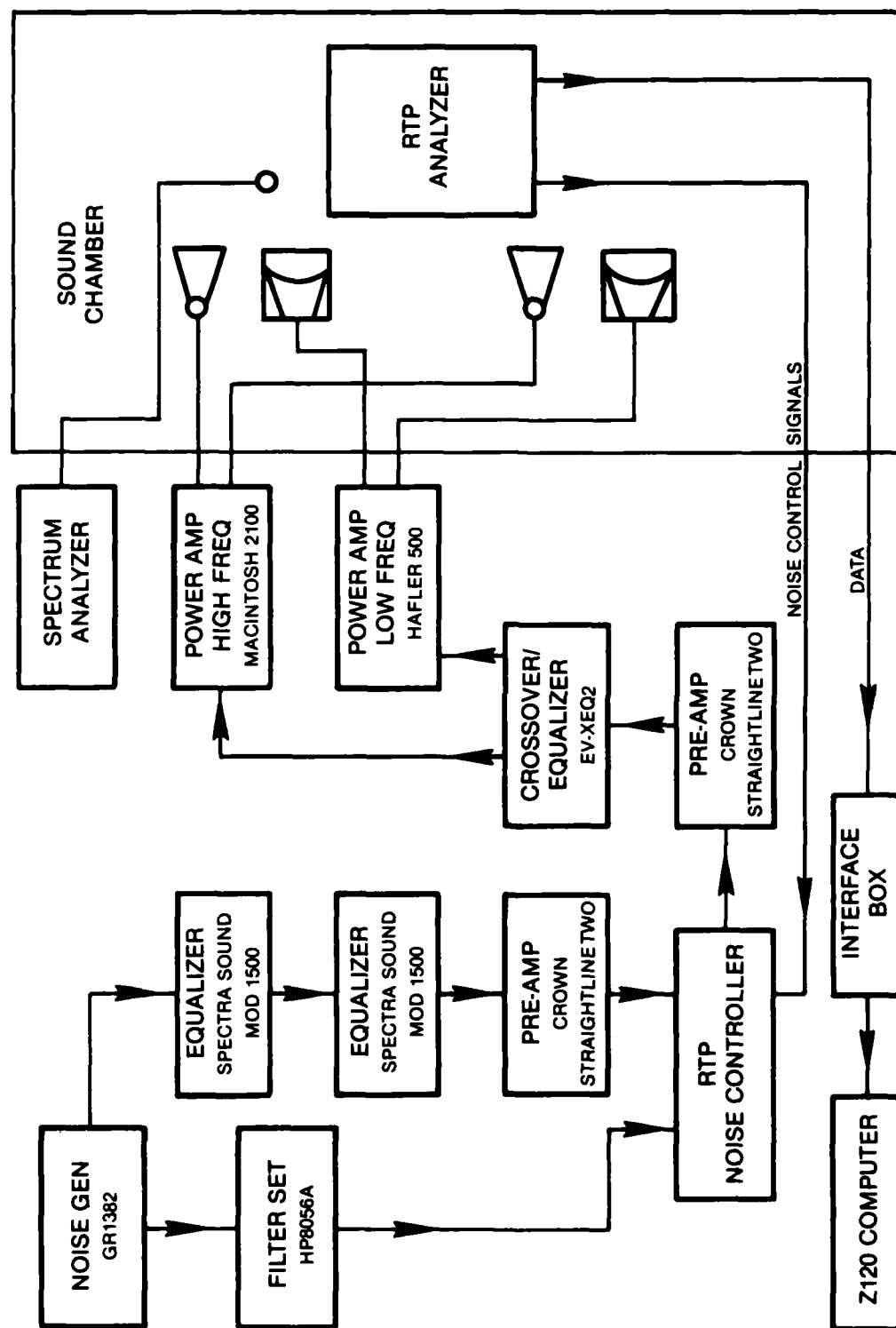


FIGURE 2. BLOCK DIAGRAM OF INSTRUMENTATION USED IN THE RTPA EXPERIMENT

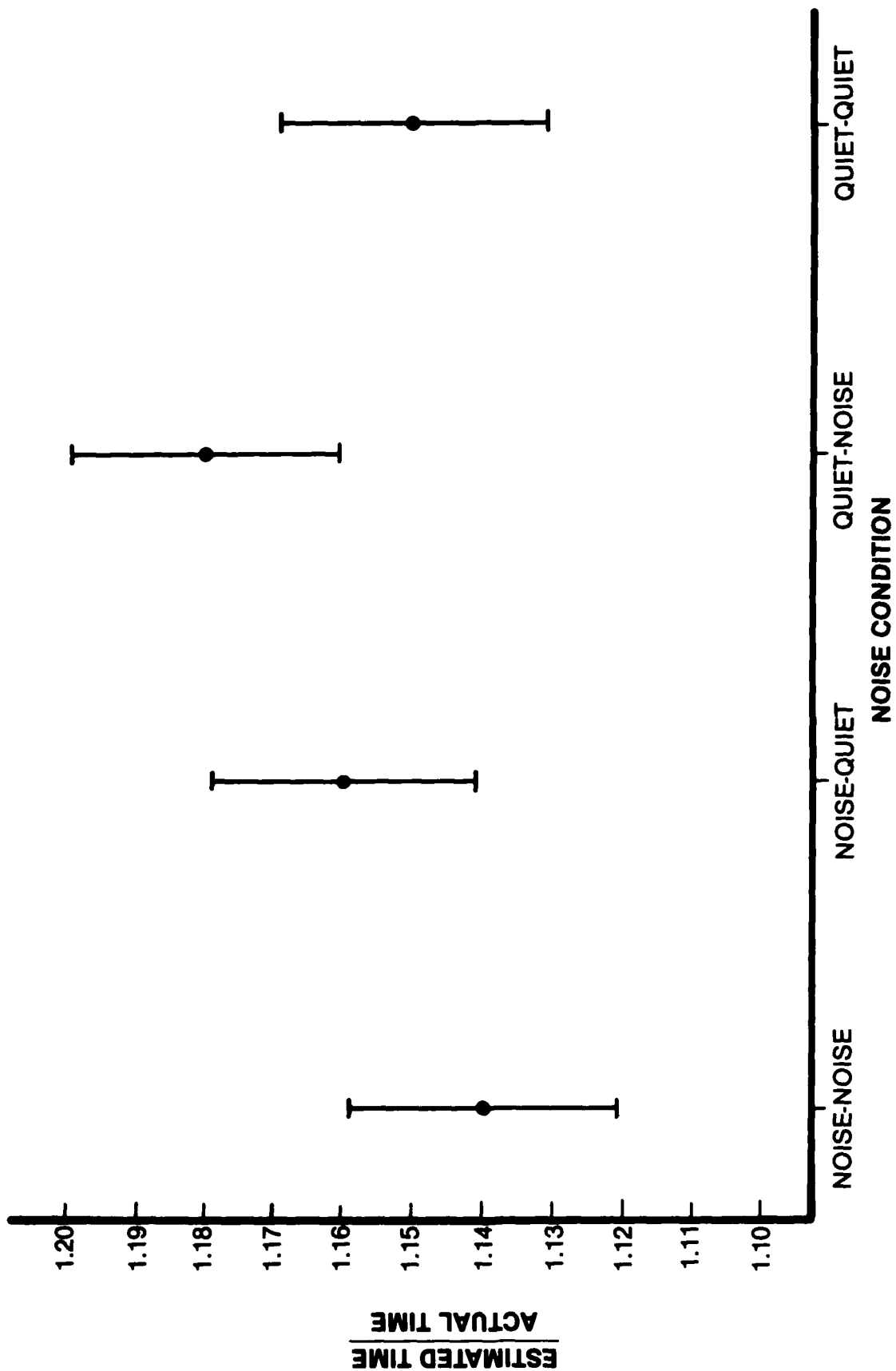


FIGURE 3. MEAN ESTIMATED/ACTUAL TIME INTERVALS AND APPROXIMATE 95% CONFIDENCE INTERVALS FOR EACH OF THE NOISE CONDITIONS

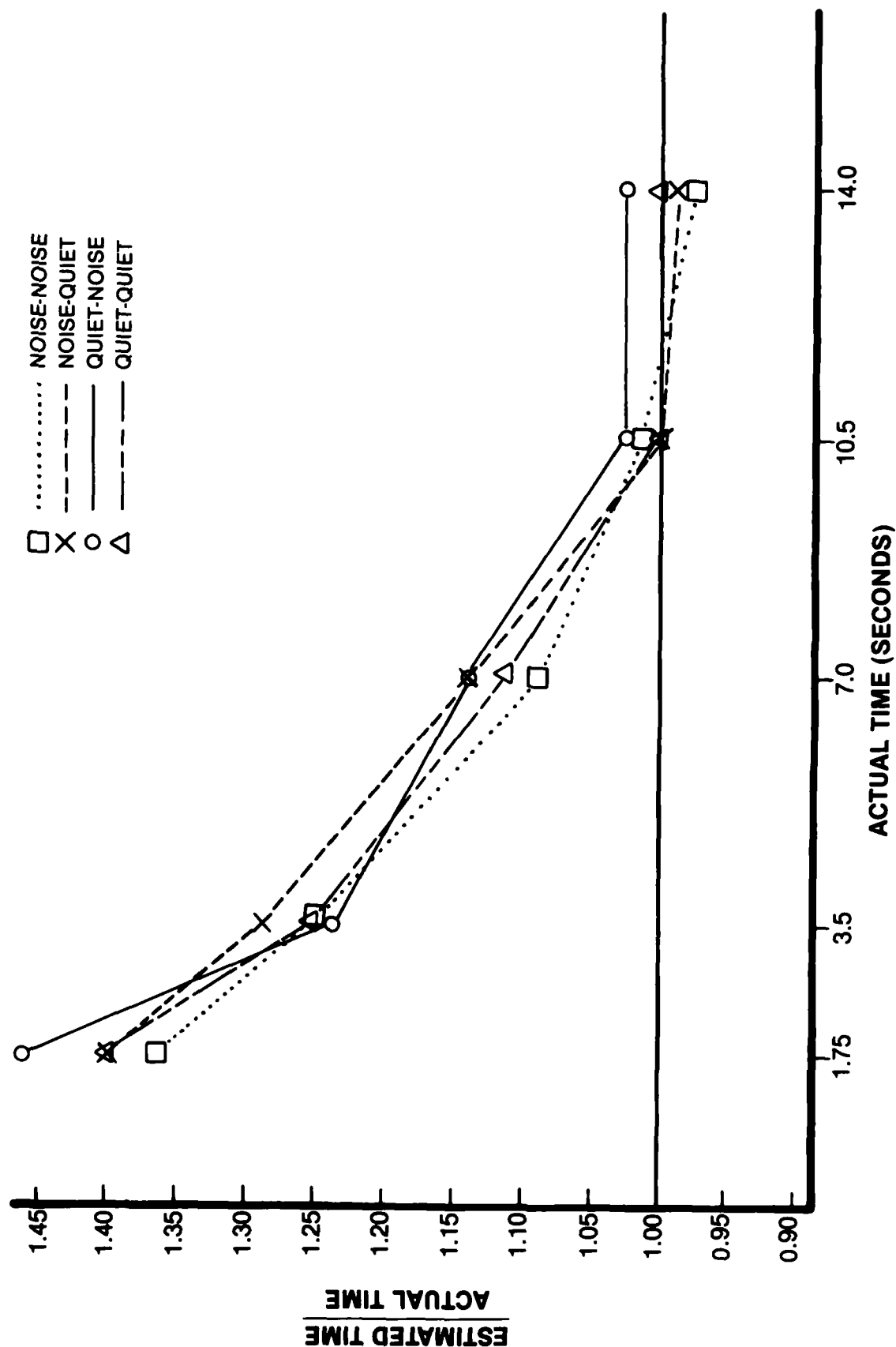


FIGURE 4. MEAN ESTIMATED/ACTUAL TIME INTERVALS

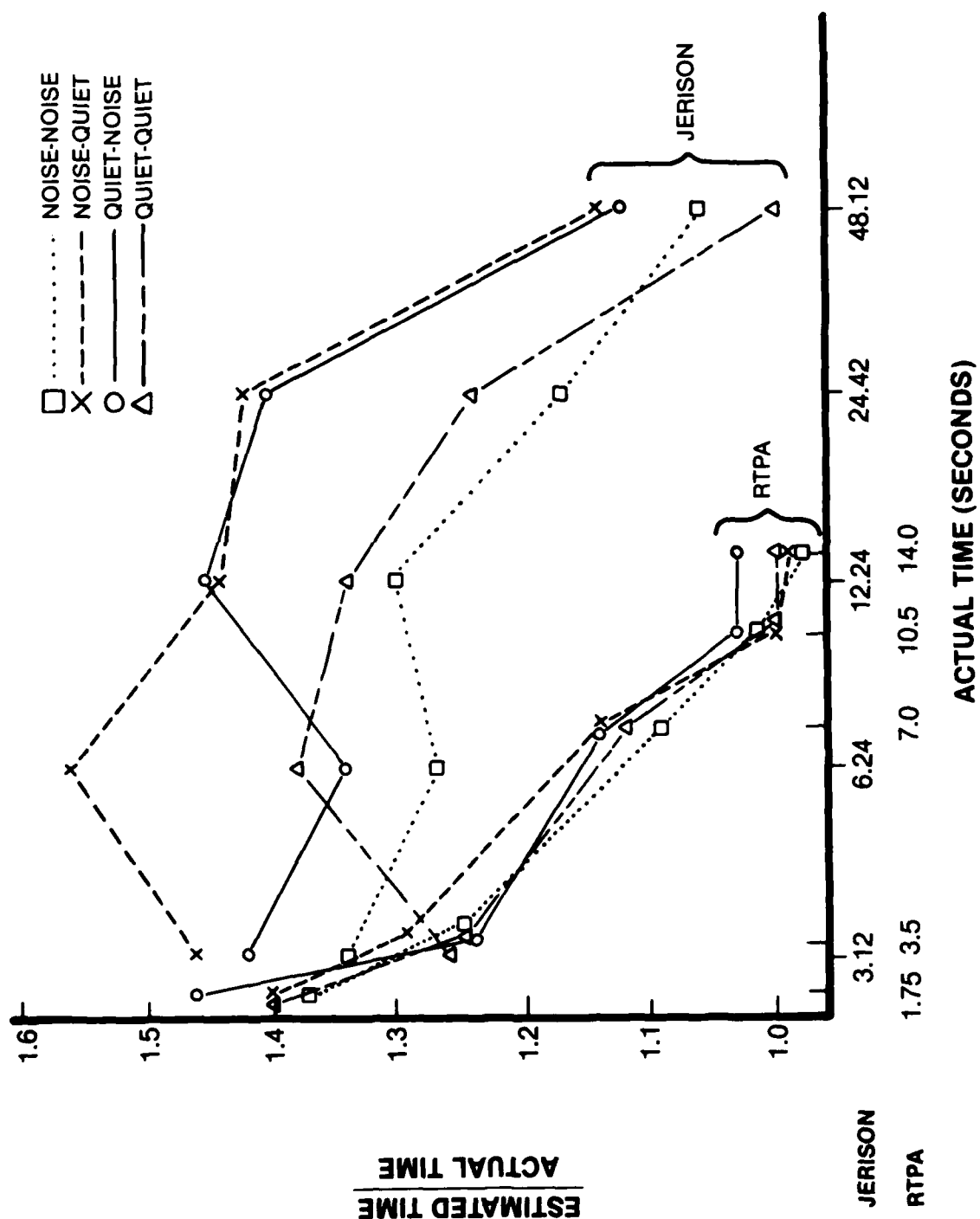


FIGURE 5. MEAN ESTIMATED/ACTUAL TIME INTERVALS FOR THE RTPA AND THE JERISON STUDIES

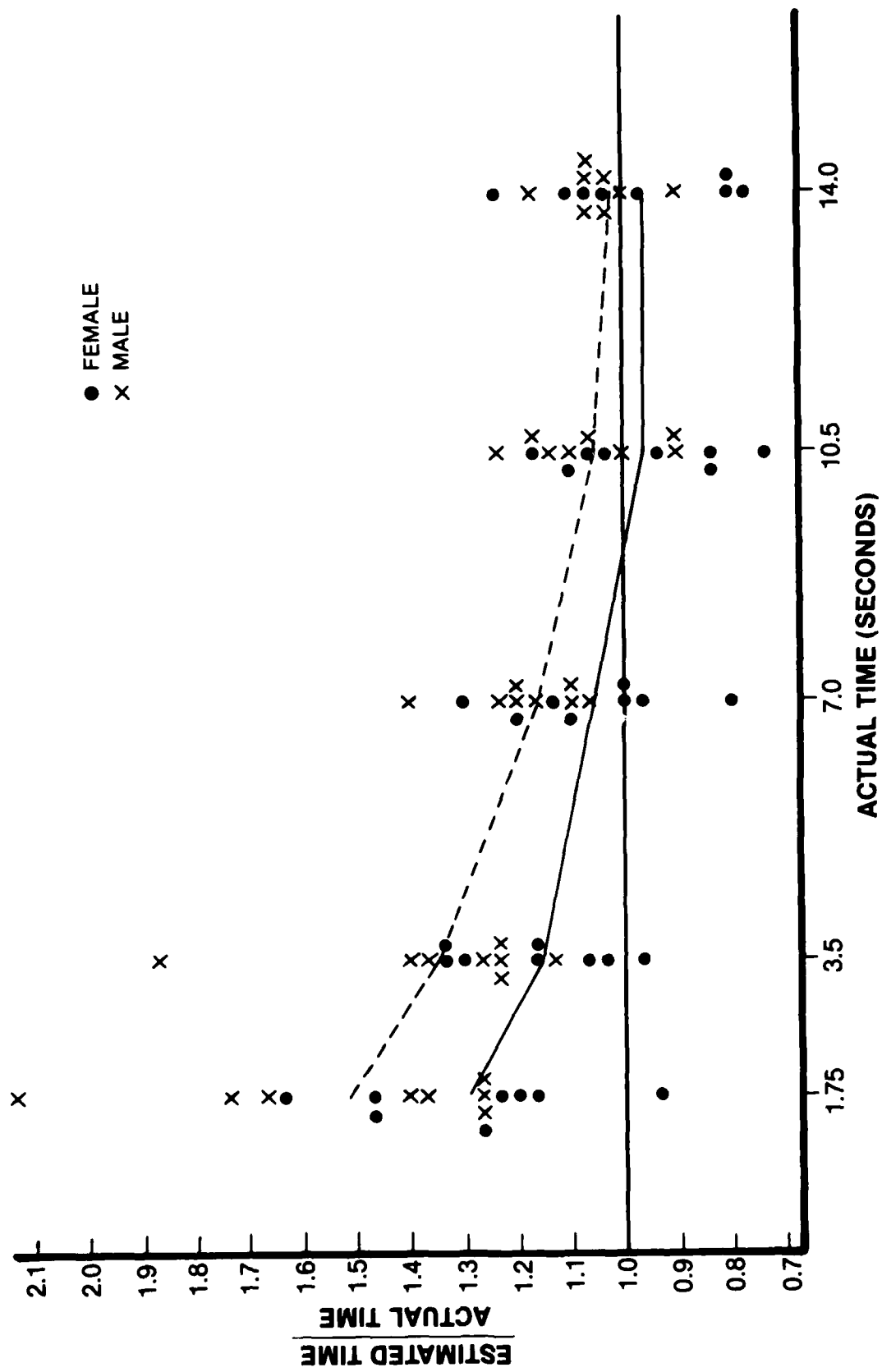


FIGURE 6. MEAN ESTIMATED/ACTUAL TIME INTERVALS OF FEMALE AND MALE SUBJECTS

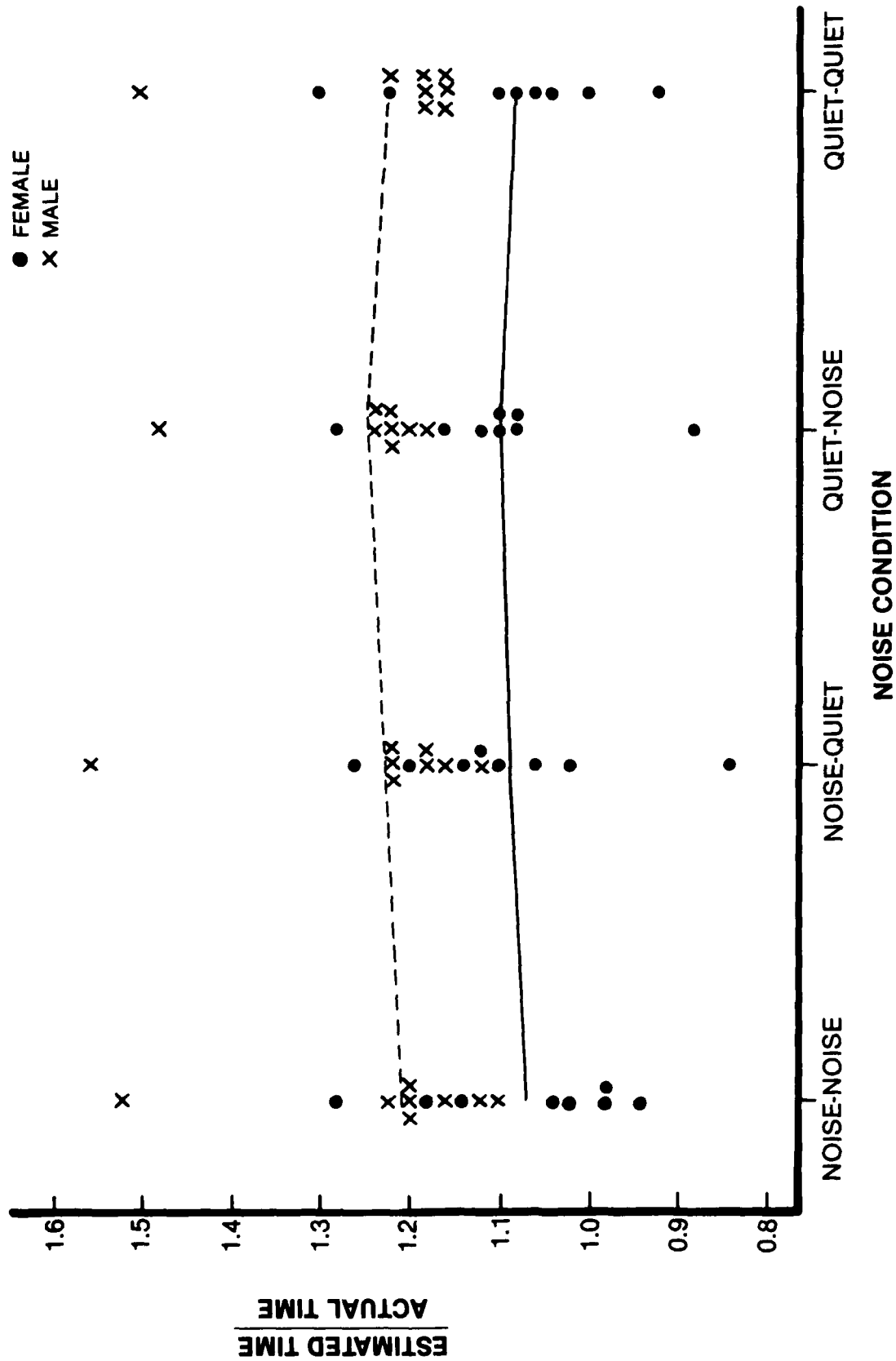


FIGURE 7. MEAN ESTIMATED/ACTUAL TIME INTERVALS OF FEMALES AND MALES FOR THE FOUR NOISE CONDITIONS



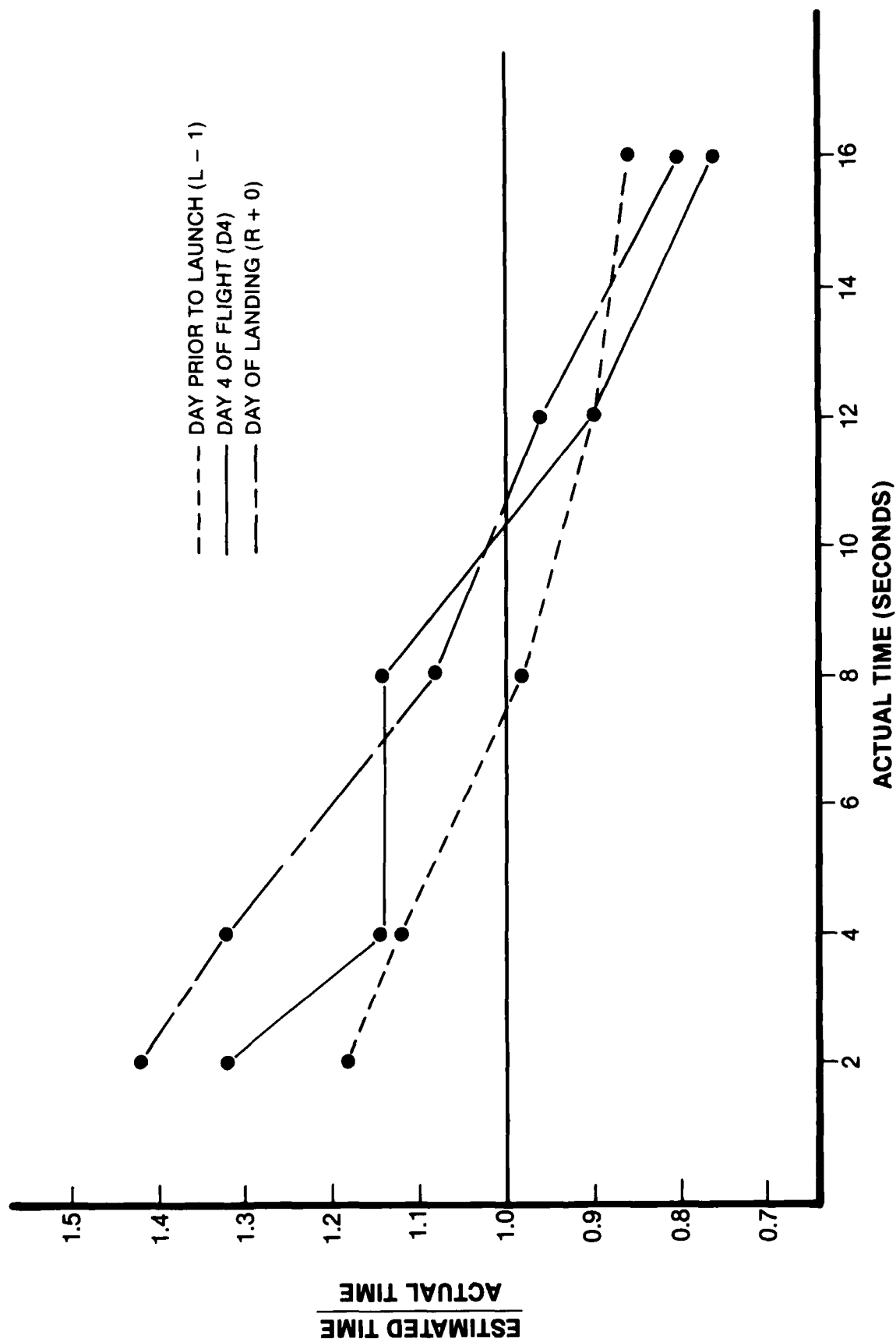


FIGURE 8. MEAN ESTIMATED/ACTUAL TIME INTERVALS MEASURED DURING A SPACE SHUTTLE FLIGHT

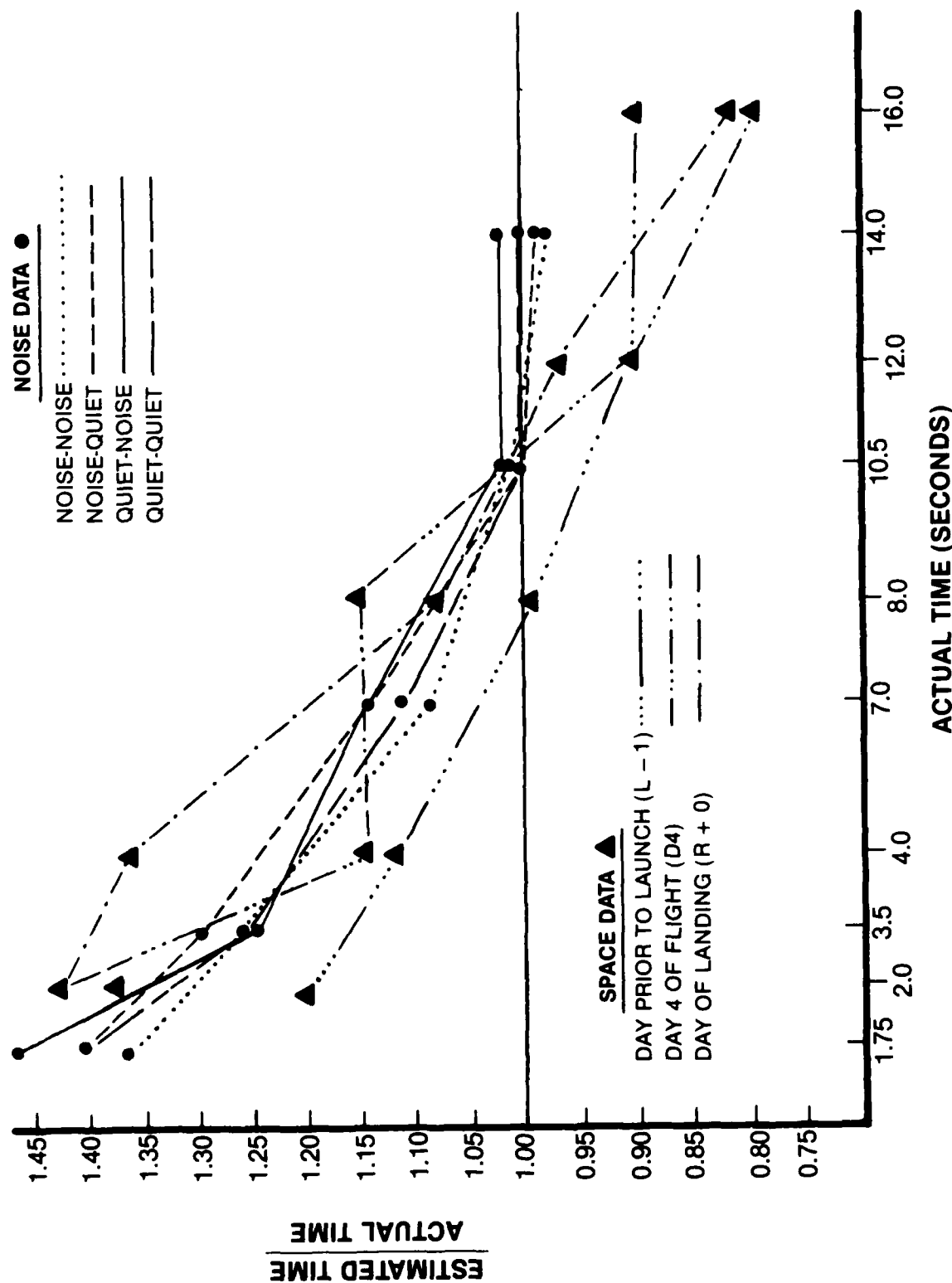


FIGURE 9. COMPARISON OF THE MEAN ESTIMATED/ACTUAL TIME INTERVALS OF THE SPACE SHUTTLE STUDY AND OF THE NOISE STUDY

END

1/1-S6

DTIC